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(71) Applicant and
(72) Inventor: LEIBER, Heinz [DE/DE]: Theodor-Heuss-Strasse 34, 71739 Oberrietingen DE). **LEIBER, Thomas** [DE/DE]: Gentzstrasse 1/5, 80796 München (DE).

(74) Representative: LENZING, Andreas: Münsterstr. 248, 40470 Düsseldorf (DE).

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(54) Title: ELECTROMAGNETIC ACUTATOR

(57) Abstract: The invention relates to an electromagnetic actuator which actuates a gas exchange valve. Said actuator comprises two electromagnets and an armature which is actuated by the latter and acts upon the gas exchange valve and comprises two spring forces which act in opposing directions upon the armature. The electromagnets have a transformation ratio $i = l_1/ l_2$ of less than 1. The armature and the poles of the electromagnet which are assigned thereto are configures in such a way that the transformation ratio i_1 of the contact magnet is greater than the transformation ratio i_2 of the break magnet.

Electromagnetic actuator

The invention relates to an electromagnetic actuator with the features of the State of the Art part of claim 1.

Such an actuator is for example described in the older Patent Application 19824 537.8.

The transmission ratio i for both electromagnets is normally the same.

The invention has the object to further improve the proposed actuator.

This object is solved by means of the features of claim 1.

For the closing magnet it is valid, that it has to have a large retaining force because of the valve closing force. On the other hand the closing magnet has to carry out a relative small lifting work because of the smaller gas forces during the closing.

Compared to this the opening magnet has to carry out a relative large lifting work because of the relative large gas forces at the outlet valve. To save energy, thus, the operating air gap should be as small as possible, which necessitates a smaller transmission ratio i for the opening magnet.

Contrary to this the closing magnet produces a higher force on the valve axle at a higher transmission ratio.

From these considerations the layout of the actuator with different i for the two electromagnets results.

With this layout of the electromagnets the closing magnet becomes small. The effective armature inertia is slightly increased because of the shape of the armature (e.g. trapezoidal cross-section).

The opening magnet has a small average air gap, which reduces the efficiency.

According to an improvement of the invention at least one of the magnets is formed as a characteristic line magnet. With this, it has to be taken care of, that the dimensioning rule of claim 1 is obeyed to. Preferably, the opening magnet is formed as a two-pole immersion armature, wherein the armature portion arranged opposite to the opening magnet is formed in such a way, that the armature portions immersing into the electromagnet are arranged closer to the swivelling axis than the pole ends of the yoke arranged to the immersing armature portions.

The use of such a characteristic line magnet as the opening magnet is known from EP 0739 004 A1. Compared to the second electromagnet the armature is formed as a flat armature. The electromagnets are there formed as pot magnets, wherein the armature carries out a linear up- and downwards movement. In the State of the Art the armature is glidingly supported. The air gap differences unavoidable because of the manufacturing tolerances produce relative high transversal forces, whereby frictional forces are caused. The use of a characteristic line magnet has the advantage, that the high gas forces can be easier balanced because of the higher far field-force of such an electromagnet. In the specific case of the pivotable armature the moved mass of the armature and therewith the energy requirement is kept small by the invention. The use of a single or several rolling bearings for the pivoting movement of the armature has the advantage, that transversal forces on the bearing caused by the manufacturing tolerances produce lower frictional losses. Because of the use of stamped parts for the armature and/or the yoke, which can be manufactured as fine stamping parts, the tolerances and the eddy current losses can be kept small. Furthermore, the yoke can be adjusted relative to the armature. The use of the characteristic line magnets formed according to the invention is also possible without the use of the features of A1 .

Embodiments of the invention are described by reference to the drawing.

Fig. 1 shows a first embodiment.

Fig. 2 shows a second embodiment.

In Fig. 1 two two-pole electromagnets 1 and 2 are shown, which, respectively, have a yoke 1a or 2a and a winding 1b or 2b. An armature 3 arranged to these electromagnets 1 and 2 is attached on a lever, which is pivotably supported on its left end. The support can be formed as rolling member bearings, wherein one or more rolling member bearings can be used. The spring forces acting on the armature 3 are, in this case, produced by a torsion bar, e.g. torsion bar or torsion tube 6, as well as by the valve spring 9. The torsion bar extends in the direction of the pivoting axis and at least partially in a tube 7, which is formed by the lever 8. On the other end of the lever 8, the lever acts on a valve stem 10, only schematically represented, onto which the force of the valve spring 9 acts.

The electromagnet 2 is the opening magnet.

Here, the shaded represented armature 3 has in the cross-section the form of a trapezoid with not parallel side faces. Therefore, the centre 2b of the lower armature portion lies closer to the pivoting axis 4 than the centre 3a of the upper armature portion. The poles of the electromagnets are arranged in such a way, that they are arranged to the armature portions with the centres 3a and 3b. From this results, that the transmission ratio i_1 of the electromagnet 1 is larger than the transmission ratio i_2 of the electromagnet 2. Alternatively, the armature can also have the form of a rhombus or of a polygon.

In Fig. 2, similar as in Fig. 1, two electromagnets 11, 11a, 11b and 12, 12a and 12b are provided, to which a pivotably supported armature 12 is opposed, which acts onto a valve stem 20. Here, the lever 18 is supported in rolling member bearings 15. In this case, the torsion bar 16 produces the total spring forces. Here, it is also valid, that is $i_1 > i_2$.

While the portion of the armature 13, arranged to the electromagnet 11, is a flat armature, the armature portion arranged to the electromagnet 12 is formed in this case, additionally as an immersion armature with immersion portions 13a and 13b and the poles 12c of the yoke 12a are arranged close to the immersion portions 13a and 13b in the shown position and is formed suitable for the pivoting movement, so that small air gaps are formed. As mentioned, the armature 13 and the yokes 11a and 12a

are preferably assembled from stamping parts, thus, they are laminated. Because of the rolling bearing arrangement and the yokes adjustable relative to the armature the radial air gaps can be kept very small. The system acts, in this case like a reluctance motor.

The yokes of the magnets 1 and 2 are formed as U-magnets in Figures 1 and 2. They also can be formed as E-magnets or E/U-magnets.